Skills Research Initiative
Initiative de recherche sur les compétences

Skills, Human Capital and the Life Cycle

Peter Kuhn (University of California, Santa Barbara)

Working Paper 2005 A-04

Human Resources and Skills Development Canada/Ressources humaines et développement des compétences Canada
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Abstract

This paper seeks, first, to clarify the various senses that economists attach to the term "skill" and to compare them to how the term is used by non-economists. Next, the paper draws on existing research by economists and psychologists in order to evaluate the impact of population aging on the skills composition of the work force and the adjustment capacity of the Canadian economy. Existing research suggests offsetting effects of population aging on skills. On the one hand, the capacity to acquire skills decreases with aging and this seems to be due in large part to biological factors. On the other hand, older workers have more accumulated skills, greater accumulated assets and shorter planning horizons. It might seem paradoxal that the last two factors may make older workers more likely than younger workers to make "risky" skills investments with a short pay-off horizon.

Résumé

L'auteur vise à clarifier les nombreux sens qu'accordent au mot « compétences » les économistes et de les comparer aux notions de compétences utilisées plus fréquemment par ceux qui ne sont pas économistes. De plus, en se fondant en grande partie sur des études existantes en économie et en psychologie, l'auteur évalue les répercussions éventuelles du vieillissement de la population active sur la composition de la main-d'oeuvre qualifiée et la possibilité d'adaptation à l'économie canadienne. Les études réalisées dans ces deux domaines font ressortir certains effets compensateurs du vieillissement. D'une part, tout indique que la diminution de la capacité d'acquérir de nouvelles compétences soit, du moins dans une certaine mesure, liée à des facteurs biologiques. D'autre part, trois éléments font contrepoids à ce constat : le plus vaste bagage de connaissances des travailleurs âgés, leur plus grande richesse et leurs horizons prévisionnels plus courts. Fait qui peut paraître paradoxal, les deux derniers points pourraient inciter les travailleurs âgés à investir dans l'acquisition de compétences « à risque », assortie de courts horizons temporels.

1. Introduction

It has become commonplace to observe that as the world economy integrates, "unskilled" jobs are leaving high-wage countries for low-wage countries like Mexico and China. Rather than attempting to impede this exodus of unskilled jobs, a variety of influential commentators such as the OECD recommend that developed countries like Canada should specialize in the production and export of skill-intensive products and services. One concern with this recommendation, however, is that the specifics of what, exactly, *is* "skill" and what *types* of skills are best fostered as a response to globalization, are often left undefined. A second concern refers to the rising average age of Canada's labour force. Might an aging workforce make the adjustments required to transform Canada into a "knowledge-based economy" –such as labour force reallocation, training, and retraining—harder to accomplish today than they once were?

Taking these two concerns as its starting point, this paper has two main goals. The first is to clarify the central but elusive concept of "skill" in recent policy discussions. "Skill" is sometimes used in quite different ways by academic economists versus, for example, businesspeople in charge of hiring workers. Clarifying the ways that skills are defined, classified and measured by economists versus others may go a long way in helping the nation begin a fruitful discourse about how to foster a skill-intensive economy. Second, drawing largely on existing research in economics and psychology, I assess the likely implications of labour force aging for the skill mix and adjustment potential of the Canadian economy.

In more detail, sections 2 and 3 of the paper clarify the concept of "skills". Section 2 focuses on the *definition* and *classification* of skills; Section 3 on the *measurement* of skills in practice. The remainder of the paper relates skills to workforce aging. Section 4 reviews the economics literature on skill acquisition over the life cycle; Section 5 does the same for psychology. Section 6 makes a first, largely illustrative attempt to synthesize the economics and psychology literatures by testing some psychological propositions using data on displaced workers. Section 7 discusses implications for policy and for further research.

2. Defining and Classifying Skills

In general, economists think of skills as any attribute attached to a single person which raises that individual's productivity. In this very broad sense, economists' definition corresponds quite closely to the use of the word "skill" in everyday conversation. In contrast, for example, to sociological notions of shared rules of interaction, "social capital", or corporate culture which may also raise productivity but operate more on a group level[1] it is my impression that both economists and "real" people tend to adopt a more individualistic view of skills as personal attributes which (to varying

[1] See for example, Stasz (2001, p. 388): "The sociocultural perspective shifts the focus of inquiry from individuals to interactive systems or social settings that are larger than the behavior and cognitive processes of a single person…Numerous studies have examined skills in specific occupations from this perspective".

and measurable degrees) "follow" the person who possesses them into different workplaces, firms, regions, countries, etc.

While agreeing in general with common usage, considerable room for misunderstanding of economists' notions of skills remains. One key source of confusion concerns how skills are classified into "types". To see this, consider how a randomly chosen worker is likely to respond when asked "What types of skills do you have?". Although I can offer no hard evidence on this point, I would argue that most workers will refer to their abilities to perform certain tasks, such as repairing cars, programming in *Stata*, motivating a group of people to achieve some goal, defending someone in court, etc. In other words, in "default" everyday usage, skills are classified according to their *content*, i.e. the specific *tasks* those skills enable one to do. Interestingly, while task content is *one* way in which economists classify skills, it is not the predominant way. Whatever the reasons for this –some possibilities are discussed below—it can lead to confusion. To that end, in the remainder of this section I describe the three main ways in which economists tend to categorize skills. These are (a) according to how and where the skill was acquired; (b) according to how *portable* the skill is; and (c) according to some measure of its content. Once we recognize these differences, it is easier to see the relationship between how economists and other people think about skill.

a. *Where* are skills acquired?

Labour economists recognize that skills can be acquired in a variety of different ways, and tend to analyse skills acquired in different ways separately. Most traditionally, economists tend to distinguish skills acquired in schools from those acquired on the job, and analyse these separately in the huge literatures on education and on-the-job training (see Becker 1975 and Mincer 1974 for seminal contributions). A simple reason for using this criterion to classify skills is the ready availability of data, particularly on schooling. A third important source of skills and competencies is of course an individual's family, either via genetic inheritance or parental care. This is currently the subject of a burgeoning literature in labour economics (see Ruhm 2004 for a recent example).

b. How *portable* are skills?

In part because economists are interested in how economies (and individuals) adjust to change, a key preoccupation is the portability of an individual's skills. This has led to a profusion of skill "types" based on which boundaries that a skill can cross and still maintain its usefulness. These include (all with the obvious definitions), general versus firm-specific skills (Becker 1975), industry-specific skills (Neal 1995), and occupation-specific skills (Shaw 1984; Kamborov and Manovskii 2002) . Clearly, all the above are relevant to the amount of earnings a displaced worker is likely to lose. Recently Kuhn and Sweetman (1999) have also defined *alternative* skills –which are useful *only* in alternative employment. Immigration analysts (e.g. Sweetman 2001) have also defined country-specific skills (including language; in Canada this would be a province-specific skill). Analysts of marriage and divorce (and their labour market implications) have even defined marriage-specific skills (Becker et al. 1977).

c. What *tasks* does a skill enable one to do?

Perhaps because the list of possible tasks in an economy is so huge, and changing so constantly, economists (in contrast to everyday usage) have been less likely to categorize skills in this manner. Since jobs (or for that matter occupations) are often modelled as bundles of tasks (see for example the job design literature stemming from Holmstrom and Milgrom's 1991 seminal article), these difficulties are reflected in the complex, resource-intensive, and constantly changing occupation and industry classification systems employed in all developing countries, such as the Dictionary of Occupational Titles (DOT) in the U.S. Classification error is a large and well-known problem with occupational classifications, especially when linked to survey data where workers are assigned to occupations based on open-ended self-reports of "type of work". Still, economists have sometimes made use of DOT data, and have also used certain summary measures of skill content, such as literacy and numeracy, in their empirical work.

Of course, as with any typology, there are overlaps between these categorizations. For example, Lazear (2003) has recently drawn a useful link between task-based skill measures and the notion of firm-specific skills. Also, it is common for economists to think of schooling as providing only general skills; that said, certain types of formal schooling (such as medical school and many community college courses) provide skills that are highly occupation-specific.

3. Measuring Skills: How *Much* Skill Does a Person (or Country) Possess?

It is one thing, of course, to argue that a person possesses (some of) a certain type of skill. But some people who possess the same types of skills are nonetheless much more productive than others. A harder question, of importance for understanding education and training policy, is thus to quantify how *much* skill a given person (or population) has. In this section I describe the four main methods used by economists to measure skill quantities, again with a view to making economists' use of the word "skill" more transparent to nonspecialists. I also point out salient advantages and limitations of each broad measurement strategy. The four main methods I have been able to identify in the literature are, in turn, measures based on the quantity of resources devoted to skill acquisition –I call these "*input*-based" methods; measures based on *tests* such as math and literacy exams; those based on the *wage* commanded; and *job-content*-based measures.

a. Input-based measures of skill

Input-based measures of skill use the amount of time spent investing in a skill as a proxy for the amount of skill a person has acquired. By far the most common input-based measures in the economics literature are years of education and years of work experience. Both are widely used in the study of earnings levels, earnings inequality, productivity and growth, and have the advantage of being widely measured and consistently defined across many data sources, years and jurisdictions. For skills acquired in the family, it is harder to measure "inputs", though a growing literature on child development uses measures of parental time inputs (in particular, hours or months of the mother's non-working time) as indicative of investments in children's skills (see for example Ruhm 2004).

One key limitation shared by all input-based measures of skill is the usual one that arises when inputs (e.g. years spent in school) are used as a proxy for outputs (skill): no accounting is made for possible variations in efficiency of production. In the case of education, not all schools (or school systems) are equally effective in imparting useful skills, and not all individuals benefit equally from the same year of education. Clearly, the huge literature and debate over school quality and education reform (see Hanushek and Raymond 2004 for a recent review) would be meaningless if human capital could be simply measured by number of years a person spent in the education system. The literature on school quality should thus be considered an indispensible component of the literature on "skills".

A second key limitation of input-based skill measures is the fact that skills can be lost as well as acquired, through the twin mechanisms of depreciation and obsolescence. Depreciation, or atrophy of skills occurs when skills need to be used or maintained in order to remain functional. Obsolescence occurs when a technological or market change (such as trade with low-wage countries) makes even a well-maintained skill (such as typesetting) useless. Accounting for skill depreciation while workers are unemployed or withdrawn from the labour market, and the important effects of economic turbulence in destroying the value of certain skills should be an important component of understanding what kinds of skills a nation needs.

Finally, most existing input-based skill measures suffer from an unnecessary coarseness and lack of detail, for example because they simply count the *number* of years of school attended. Much can be learned about the determinants of earnings structure by gathering data on the detailed *ways* in which (say) time in school was spent. For example, Altonji (1995) shows that the types of courses taken in high school have important implications for adult wages; Cho (2004) shows that increases in women's participation in high-school math and science courses helps explain why women are now a sizable majority on U.S. college campuses. Even extracurricular activities in high school matter for labour market success (and by inference for skills), as Kuhn and Weinberger (2004) have recently shown.

b. Test-based measures of skill

A second set of devices used by economists to measure "skills" are tests of achievement or aptitude; interestingly these tests are typically designed by psychologists. Common test-based measures include tests of literacy and numeracy, standardized achievement tests such as those recently introduced in Canadian elementary and high schools, internationally-standardized achievement tests such as the PISA project, college-admissions tests like the SAT and ACT in the U.S., and tests concerning more practical work-related knowledge, such as the Knowledge of the Work of Work (KWW) test used in some U.S. studies of achievement.[2] An important advantage of these tests is that they provide reliable measures of skill that are distinct from resource inputs into skill acquisition and are correlated with future academic and labour market success. A disadvantage is that, once education and experience are held constant, their additional explanatory power is surprisingly modest (for a review see Bowles, Gintis and Osborne 2001). Indeed everyone (including the testers) agrees that tests are imperfect, and perhaps unnecessarily unidimensional.[3] But without tests, we are left without an important measure of the output from an education system (as distinct from the inputs into it). Especially since standardized educational testing arrived so late to Canada, more information of this kind, especially when included in other social surveys, seems essential to formulating a national skills strategy.

c. Wage-based measures of skill

Used improperly, economists' third main method for measuring the amount of skills a person has – wages—is purely tautological. Arguing that high-wage persons earn more because they have more "skill", when the only evidence they have more skill is their higher wages, gets us exactly nowhere (except perhaps to provide an "explanation" for whatever amount of wage inequality happens to exist). It does not follow, however, that evidence on wages is useless in defining and measuring skill levels. For example, one very important way in which wages have been used to refine our measures of skill is in measuring the *portability* of skills, as well as in understanding skill depreciation and obsolescence. Studies of the wage losses of displaced workers, and of how those wage losses depend on firm tenure, occupational tenure, and industry tenure in the lost job, as well as how they depend on whether the worker changed occupation and industry upon displacement, tell us a lot about the portability of different kinds of skills and the process of obsolescence. They also tell us about time trends in the level of generality of skills. Economy-wide summary measures of human capital that use relative wages of different education/experience groups in a given base year to construct an overall fixed-weight

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[2] Measures of education that are *credential*-based (i.e. the attainment of a university degree) rather than based on the number of years spent might best be thought of a a kind of hybrid between purely input- and test-based measures. The same could be said of success in *subsequent* education, which is sometimes fruitfully used as a measure of skills acquired at a lower educational level. For example, the high school graduation rates of a group of elementary school students are sometimes used to measure the quality of those students' elementary education (e.g. Bedard and Do, 2004).

[3] A heated debate continues in psychology between proponents of a unidimensional view of general intelligence, or "g" such as Herrnstein and Murray (1994), and mulitidimensionalists such as Sternberg (1988); parallel to but distinct from this divide is the debate on the relative roles of nature and nurture.

"human capital" index are also useful in growth accounting, and are not directly subject to the tautology critique noted above.

Wage measures have also been used to distinguish between two types of inequality in an economy –wage inequality across observable (usually experience/education) groups, sometimes called "observed skills"[4], versus "residual inequality", or "unobserved" skill (see for example Lemieux 2004). It is in the latter case where the greatest danger of tautology exists, and noneconomists are correct to question economists' labelling of that portion of a person's earnings economists are unable to explain as "unobserved ability" or unobserved skill. Even here there is a meaningful distinction, however, between a person's *rank* in the wage distribution (sometimes taken as an indicator of the amount of skill or human capital they possess relative to other workers) and the distance between the "rungs" of this earnings ladder (often taken as a measure of the *price* of a unit of skill, under the assumption that –at least in the short run—the distribution of skills in the adult population changes only very slowly). There is also a meaningful distinction between unexplained components of wages that are permanently attached to a person, and those which change from year to year or from job to job, with the former closer to "unobserved ability" and the latter more representative of firm-specific skills, or even measurement error in wages. In other words, the error term in a wage regression can be meaningfully decomposed into components corresponding loosely to skills with different degrees of portability and other factors like statistical noise.

d. Job-content based measures of skill.

For over half a century now, governments in North America have financed detailed studies of the task- and skill content of jobs, generally as an input to the construction of various Dictionaries of Occupational Titles.[5] Perhaps because of the almost unmanageable level of detail; perhaps because of concerns about the arbitrariness of some skill and job definitions and resulting measurement error; and perhaps because of the surprising paucity of data sets that match detailed DOT-type job characteristic data to standard microdata on individual labour market outcomes, data of this type is only very occasionally used by economists. Still, some interesting work has been done, including Scoville's early work on changes in the skill mixes of the Canadian (1967) and U.S. (1969) economies. More recently, Autor et al. (2003) have used this data to address a very important question: what has been the impact of the computer and internet revolution on the types of skills demanded in the U.S economy? Kuhn and Sweetman (2003) have used this type of data to understand the relation between multiskilling and the wage losses of displaced workers.

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[4] An fortunate choice of terms, since it is merely the inputs (schooling and experience) to skill production, not the skills themselves, that are observed.

[5] Interestingly, some of the key measures of job content in the DOT –in particular "specific vocational preparation" (SVP) and "general educational development" (GED)—are, in part, input-based because they refer directly to the duration of training required for the job. Other aspects of the DOT refer to a wide variety of factors, including the type of personality considered suitable for the job.

Aside from the problems mentioned above, another key problem with using *job* content to measure the skill of the *person* occupying that job is that people are rarely perfectly matched to their jobs. Some may be overqualified, possessing skills that are not used in the job; others may be (perhaps temporarily) occupying jobs they are not qualified for. While users of such data argue that, on average, jobs' skill requirements might be unbiased estimates of the skill endowments of their occupants (see for example Green et al., 2001, p. 416); to my knowledge no quantitative studies of this question exist.

In sum, while important difficulties and provisos do exist, in my assessment job-characteristic-based measures have been somewhat unjustly underutilized by economists and – as illustrated by recent studies such as Autor et al's- have the potential to shed important light on changes in the kinds of skills in demand in evolving economies. Clearly, perhaps *the* $64,000. question in the area of skills today is: "what *can't* computers do, or what kinds of skills are *complementary* with computers?" Detailed studies of job content, (including those using first-hand observation of the production process such as Autor et al. 2000) combined with data on wages and employment, may help answer this question.[6] Indeed, job characteristic surveys are routinely used by firms in setting wages (they are the bread- and butter of private compensation consulting firms like Hay Associates). Access to the proprietary databases of such firms for research purposes could also be of value in addressing issues of this kind, if that could be arranged.

Taken together, despite all the noted shortcomings the above four ways of measuring skill in economists' "toolkit" can still provide a fairly comprehensive measure of the amount of productivity-enhancing "knowledge" or skill embodied in any given person, or aggregate workforce. However, some important gaps do remain, in particular regarding skill types economists are not accustomed to measuring, but which may be particularly relevant for the "new", or "knowledge-based" economy. To see this, it is instructive to refer back to popular discussions of the kinds of skills required to perform jobs today. Many skills mentioned in such discussions, while occasionally recognized by economists, tend to receive very little attention in the economics literature. For example, in a recent U.S. nationwide survey, the National Association of Colleges and Employers (2000) found that employers' five most highly-valued personal qualities, in order, were communications skills, motivation/initiative, teamwork skills, leadership skills, and academic achievement/GPA. These were followed by interpersonal skills, flexibility/adaptability, technical skills, and honesty/integrity; with "work ethic" and analytical/problem-solving skills tied for tenth place. Of these eleven qualities, only two

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[6] As important as this question is, its answer remains far from obvious. Certainly, Goldin and Katz's (1998) examination of the historical record shows that there is nothing inherent in technological change *per se* that makes it inherently "skill-biased" (i.e. complementary with skilled labour). Recent research on artificial intelligence (see Pinker 1997 for a survey) makes it painfully clear that many tasks that even the least skilled human can do with ease (e.g. walking, seeing) are dauntingly difficult for computers, while of course other tasks such as calculation and memory storage/retrieval are much easier for computers than people. On their own, these facts would tend to make computers *complementary* with the former skills and substitutes for the latter. Finally, Card and DiNardo (2002) raise a number of important questions concerning whether skill-biased technical change (related for example to the computer and internet revolution) plays much of a role in the recent increase in U.S. wage inequality.

(academic achievement and analytical/problem solving skills) seem to correspond very closely to *any* of the definitions of "skill" outlined above. Employers of low-skilled workers surveyed by Holzer (1996) place more weight on a "good attitude" than on "basic skills" among their new hires. Employers' valuation of these "non-cognitive" qualities, or "soft skills", is further underscored by the increased use of psychological testing of new job applicants for such traits (e.g. Richtel 2000). Employers spend real money on these tests, which tend to focus much more on a mix of personality traits than on cognitive abilities, and use the test results in their hiring decisions.

More analysis of production and demand for these "softer" skills should be an important part of the research agenda of a country like Canada, especially as computerization and international trade may be providing better substitutes for "hard" skills, whether via programming routine tasks into a software routine, or by emailing routine programming work to Bangalore. Such research might require different modes of analysis (e.g. first-hand observation of the work process) and the participation of social scientists other than economists with expertise in these research methods. Such studies may also need to make use of less familiar measures of skills. One such measure –firms' internal employee performance evaluations-- have been widely studied by psychologists (see Barrick and Mount 1991 and Tett et al. 1991 for literature reviews). They are sometimes used by economists involved in litigation over discrimination issues, but to my knowledge almost never make it into the published economics literature (Medoff and Abraham 1980 is an old but notable exception). Another "nonconventional" option is employees' *self-assessed* skill measures. These are sometimes viewed with considerable skepticism by economists, even those sympathetic to notions of "soft" skills. That said, Kuhn and Weinberger (2004) have had some success with a self-assessed leadership measure; in their case the endogeneity problem is strongly mitigated by a large time gap between the taking of the skills and earnings measures.

4. Skill acquisition over the life course: what do economists know?

Since at least Ben-Porath (1967), economists have argued that the optimal pattern of skill acquisition over the human life cycle begins with a period of full-time investment (schooling), followed by a period of part-time investment (work combined with on-the-job training), followed respectively by periods of replacement investment only and a final period where skills are optimally allowed to depreciate as retirement approaches.[7] This argument provides an intuitive rationale for the quartic life-cycle earnings profile that has been an empirical regularity for North American men as long as data have been available (Murphy and Welch 1990).

While providing a useful jumping-off point, the Ben-Porath model is, of course, strictly applicable only to the situation it was meant to represent: male workers, acquiring a purely general skill, in a world where the demand for that skill is stable over

[7] It is noteworthy, in light of section 2a of this paper, that this 1960's description of human capital investment over the life cycle omits the stage where children are cared for by parents in the home (or in day care). The crucial role of investments during this life stage for a society's human capital is just beginning to be addressed by the economics profession.

the worker's lifetime. For women, who may plan to take time away from the labour market (or at least reduce their hours and effort) for child care, this simple investment timing strategy may not be appropriate. Also, if skills are of many different types, and the types of skills demanded are subject to rapid and unpredictable change, an optimal investment strategy might involve postponing the acquisition of some skills until some of that uncertainty is resolved. This in turn raises a theoretical question that has not, to my knowledge, been addressed in the literature: under uncertainty regarding future skill demand, which *types* of skills are best acquired at what point in the life cycle?

While a real model needs to be worked out, we can guess at some of its answers. Skills that are best acquired late in life should be (a) relatively easily learned late in life – see the next section for psychological evidence on this--; (b) complementary with general experience (e.g. leadership; training of junior workers?); (c) subject to the *greatest* unpredictability in demand; and (d) the *least* portable and *most* vulnerable to obsolescence (because of horizon effects: the long-run value of skills is not relevant to workers near the end of their working lives).[8] Perhaps paradoxically, then –abstracting from any age-related changes in the cost of learning new skills--, *an aging workforce actually provides an **opportunity** for Canadians to invest in "risky" skills at a lower opportunity cost than usual.* As we shall see in the next section, however, the proviso concering age and learning costs is an important one.

How portable are the skills of older Canadian (or U.S.) workers? How vulnerable to obsolescence are they? Concerning these issues, a fair amount is already known in the economics literature. As already noted, evidence on skill specificity is available from the literature on displaced workers; earnings losses of displaced workers are in fact one of the main sources of information about the degree to which a typical worker's skills are firm-, industry-, or occupation-specific. This literature shows that wage losses can range up to 30 or 40 percent for certain types of job changes (displacement of older, high-tenure men, for example), and that wage losses are greater for industry- and occupation changers, suggesting that some skills are not portable across those boundaries. The displacement literature also provides some information about earnings recovery rates *after* displacement (Ruhm 1991; Stevens 1997; Chan and Stevens 2001); the main results are that, especially for older workers, earnings recovery is slow and incomplete, and that subsequent job mobility (rather than within-job wage growth) plays a large role. Information on post-displacement earnings recovery also emerges from the considerable evaluation literature on retraining programs, especially those targeted at displaced workers (see Heckman and Smith 2004 for an example). Finally, a substantial, largely European literature --e.g. Arulampalam (2001), Gregory and Jukes (2001)— suggests that skill atrophy during long unemployment spells can be substantial in magnitude, and is greater for older workers.

A final source of information on skill atrophy comes from the study of gender wage differentials, in particular the part of this literature that estimates the consequences

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[8] Of course, opportunity cost also plays a role, in the sense that it is less costly to society for the unemployed (rather than the employed) to be the ones who retrain.

of labour market interruptions for women's earnings. The Polachek-England debate (see for example England 1982) shows that, despite the predictions of human capital theory, the types of occupations historically selected by women are *not* subject to less depreciation with time out of the labour market. Other recent evidence on women reveals penalties not just to time away, but to spells of "non-standard" employment, such as part time and self-employment (Ferber and Waldfogel 1988, Williams 2000). Relatedly, recent research by Weinberger and Kuhn (2004) shows a significant acceleration in women's earnings growth late in life in a number of recent U.S. cohorts.

In sum, as the above review shows, considerable information is already available in the economics literature on the *average* level of skill specificity and *average* rates of retraining/reinvestment/recovery among job changers in developed economies. Overall, they suggest that there is considerable uncertainty in the relative demand for different skill types in North American economies, and that the consequences of a demand shift away from one's acquired skills can be severe for the individuals involved. However, from the point of view of the current paper, there remain two important gaps in this literature. One such gap is a relative lack of focus on the role of the worker's age *per se* in the process of displacement, retraining and earnings recovery. Instead, motivated by theoretical models of firm-specific capital, economists have tended to conduct deep and detailed analysis of the effects of (predisplacement) *job tenure* on displacement-induced wage losses (e.g. Altonji and Shakotko 1987, Topel 1991), treating the worker's chronological age more like a "nuisance" covariate of little intrinsic interest.

A second gap in the economics literature probably stems from the fact –already noted-- that economists rarely classify skills by their *content*. As a result, current economic research tells us very little about which *types* of skills (as defined by task content) are most vulnerable to obsolescence, which types depreciate more easily if not used, or about which types of skills are acquired more easily late in life.[9] Fortunately, however, the discipline of psychology provides some evidence on this question, which I review in the next section.

5. Skill acquisition over the life course: what do psychologists know?

a. The Bad News: Age and Physiology

As any examination of the demographics of sports (or simple reflection on the state of our own bodies) bears out, human physical performance declines after a certain peak age (which for some physical activities --like gymnastics-- is very young). I take this as given; since a nontrivial fraction of jobs in the Canadian economy still requires physical labour, this fact remains relevant to Canadian firms and workers.

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[9] The only exceptions I am aware of are England (1982), who classifies occupations by their percent female; Kuhn-Sweetman (2003) who classify occupations by a "multiskilling" index; and Galenson and Weinberg (2000) who focuses on one very specific occupation –artists.

Concerning mental performance, over the past half century psychologists have accumulated an overwhelming mass of experimental evidence of gradual, age-related decline among human adults as well. These declines are manifest across a large array of mental tasks, including memory, problem solving, perception and concentration. While psychologists seem to agree that these broad declines have a physiological basis, it is of some interest that their profession has recently revised its assessment of the precise nature of these mechanisms: changes in neuronal viability and architecture rather than age-related brain cell death are now considered the prime culprits (see Finch 1996 for a review).[10]

Supporting evidence that biology plays an inexorable role in age-related declines in human cognitive performance comes from the fact these declines share one common element across a very wide range of tasks: speed. To quote a recent review:

> "The effects in some 288 experimental conditions are primarily determined by a single aspect of the information processing requirement, namely task duration. The evidence is near-to-overwhelming that age is experienced, at least to a first approximation, as some sort of a generalized slowing… success over such a diversity of data suggests that aging effects stem from some elementary aspect of the biology of the nervous system) (Cerella 1991, pp. 220-1).

The role of speed is also illustrated by Charness and Bosman (1990)'s study of highly-ranked chess players: the mean age for world champions in tournament chess (where players are given three minutes per move) is about 30 years, compared with 46 for correspondence chess (which allows three days per move).

Given an overall scenario of declining cognitive performance over the adult life cycle, as noted it remains of interest *which* kinds of performance decline more or less rapidly with age. According to a classic lifespan intelligence study (Jones and Conrad 1933, cited in Lindenberger 2001), abilities such as memory, spatial orientation and perception decline monotonically during adulthood, with some acceleration in very old age. In contrast, verbal knowledge and certain facets of numerical ability remain stable or increase into a person's 60's or 70's. Concerning memory specifically, some of its aspects (e.g. semantic priming, implicit memory) show little decline with age; others much more. Among the latter is "working memory", required for tasks that require simultaneous storing *and* processing of information (Hoyer, 2001). This suggests that multitasking, or at least performance of tasks that require juggling lots of information, is not likely to be an advantage of older workers.

Finally, one cognitive skill often thought to increase with age is "wisdom", conceptualized by Baltes and Staudinger (2000) as an "expert knowledge system in the fundamental pragmatics of life". However, even here it appears that the experimental

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[10] The theory that a gradual loss of brain neurons, especially in neocortical areas and the hippocampus, is responsible for age-related declines in cognitive performance has been discredited by evidence showing that previous studies were contaminated by the inclusion of subjects in very early stages of Alzheimer's disease—too early to show any behavioral symptoms but already exhibiting neuronal loss (Woodruff-Pak and Lemieux, 2001).

news is bad: Attempts to measure individuals' wisdom-related performance (based on responses to vignettes concerning life management) showed an increase up to age 25 (Pasupathi, Staudinger and Baltes 2001), with no further growth between ages 25 and 75 (Baltes and Staudinger 2000). While one can question their operationalization of the concept of "wisdom", this study does raise important questions concerning (pardon the pun) received wisdom on this topic. On the other hand, Dean Simonton has made a career of studying career patterns of creativity among artists and academics, finding a wide array of patterns that differ markedly by field of expertise (see Simonton 1990 for an overview, Simonton 1989 for a focus on end-of-career effects).

In sum, there is overwhelming psychological evidence that human performance in a wide array of mental tasks declines with age during adulthood, and that this decline has a biological basis. This is the bad news from the psychology literature concerning the likely effects of population aging on the Canadian economy's potential to transform itself into a "knowledge-based economy".

b. The Good News

The good news concerning aging and mental performance comes from a variety of sources. The first such source is one of the most basic theorems in economics: even if, for example, older workers have no more wisdom than 30-year-old workers, the research described above implies they have a *comparative* advantage in wisdom-related tasks. Thus, according to standard economic reasoning, there are efficiency gains to be realized by having older workers specialize in wisdom-intensive jobs (and for that matter for an economy with an aging population to specialize more in the production of wisdom-intensive goods and services). In other words, gains from trade with older workers, even when associated with a loss in those workers' overall, "absolute" capacity, should not be ignored.[11]

Second, the rate of decline in basic cognitive capacity is not biologically predetermined. For example, considerable evidence also supports a "reverse" causal link between aging and learning: i.e. the *act* of learning may slow down specific aspects of aging and its side-effects (Schneider 2003). In fact, a widely-cited recent study (Maguire et al., 2000) provides evidence suggesting that repeated use of specific mental skills (in this case navigation) may lead to physical enlargement of associated parts of the brain.[12] More generally, psychologists conceive of human brains as malleable ("plastic"), with considerable reserve capacity. According to a recent literature survey, "Age-related losses occur for many aspects of brain aging, but there is also growth and stability for

[11] A simple yet important example of such gains from trade comes from a recent occupational health study, which showed that changes in older workers' job profiles (in this case reducing the level of physical strain while increasing experience-based duties such as training younger workers) can significantly improve both the health and productivity of older workers (Ilmarinnen et al. 1991).

[12] The study was based on brain scans of London cab drivers. While it is possible that persons with large hippocampuses might self-select into cab driving, the authors also found an association between the amount of time a subject spent taxidriving and the size of his hippocampus.

some aspects of brain function throughout life. Concepts of brain plasticity and brain reserve capacity give emphasis to the potential of individuals to continue to improve, maintain, or optimize behavioral function in response to insidious losses associated with normal aging..." (Hoyer 2001, p.1321). Also, according to a large literature in adult education, older individuals' ability to acquire new information can be significantly improved by teaching them simple learning techniques such as mnemonics and other strategies for organizing new information (Kruse 2001). According to this literature, these strategies are especially relevant and effective for the types of tasks (e.g. free recall) in which older workers tend to underperform younger adults. Finally, mental performance in older adults is strongly influenced by their physical health. Since physical health among this group has been improving significantly over the past few decades, this is further cause for optimism.

Third, and most important, a distinction needs to be made between *stocks* and *flows* of knowledge or skills. In a striking parallel to the economic theory of human capital, psychologists' Lifespan Theories of Cognitive Development (LTCD's; see Lindenberger 2002) all make the distinction between (a) the capacity to invest—i.e. to acquire new knowledge, and (b) the stock of knowledge, or the capacity to think and act on the basis of acquired knowledge. Critically, the experimental evidence of decline cited in the previous subsection refers mostly to the "learning" or "flow" element of cognition. Thus, as long as *some* learning takes place (and is not overshadowed by depreciation of the existing stock of knowledge) a person's stock of acquired knowledge will continue to grow even as his or her capacity to assimilate new information declines. As a result some psychologists see the aging process as a race between declining biological "mechanics" –sometimes called "fluid intelligence"-- and a stock of knowledge and skills acquired from one's culture over a lifetime –sometimes called "crystallized intelligence"--, with the former ultimately (but perhaps very belatedly) winning out. Precisely as a result of "crystallized intelligence", performance of complicated cognitive tasks does not decline as rapidly with age as might be predicted from what is known about declines in the efficacy of basic cognitive processes (Willis 1987). Of particular relevance to the labour market and workplace, the use of "crystallized intelligence" to compensate for losses in biological capacity has been demonstrated in occupational studies (for example Krampe's 1994 study of pianists).

Evidence on the distinction between stocks and flows of knowledge is provided in Figure 1, taken from Papalia et al. (2002, p. 201). In what is called the "classic aging pattern", scores on verbal psychological test hold up much better with age than scores on "performance" tests. What could explain this? According to Papalia et al.,

> "For one thing, the verbal items that hold up with age are based on straightforward knowledge; unlike the performance tests, they do not require the test taker to figure out or do anything new... In addition to processing new information, the performance tasks involve speed and perceptual and motor skills. Part of the age difference in performance on this type of task is attributable to muscular and neurological slowing..." (pp. 200-201).

This would seem to imply that an economy with an aging workforce, such as Canada's, may have a comparative advantage in the production of goods and services that require intensive inputs of *accumulated* knowledge (at least to the extent that such knowledge has not been rendered obsolete by technical change), rather than the acquisition of new knowledge. Identification of such products and services is, however, a much harder question.

Finally, it is important to note that despite an average decline with age, the *level* of ability to learn new things and the stock of existing knowledge and skills varies considerably across older persons. For example, recent clinical evidence that estrogen may slow normal age-related neurodegeneration (Hoyer 2001) could imply that --since the process of decline begins later-- older women are more adaptable than older men. This is supported by evidence of performance on a wide variety of psychological tests; for example men's spatial orientation, vocabulary and verbal memory peak in the fifties; women's in the early sixties (Willis and Schaie 1999). The same is true of men's *overall* functioning in studies like the Seattle Longitudinal Study. Why do older women do better? As Papalia et al., (2002, pp. 207-208) so succinctly put it, "Terminal drop may be a factor: at any age, more men than women are close to death". That said, Papalia et al also discuss interesting differences in men's versus women's age-related declines in mental performance –for example women's perceptual speed declines faster than men's-- and note that some of these gender differences could reflect cultural differences in the skills men versus women have been encouraged to develop. Overall, these results on gender differences suggest that the presence (and re-entry) of a large number of healthy older women in the Canadian labour market may be a net mitigating factor for the effects of aging on workforce adaptability. This notion is supported by Weinberger and Kuhn's (2004) recent evidence showing faster earnings growth among older women than men in *all* recent U.S. cohorts of workers.

In addition to differences in average performance between demographic groups, it is also important to remember that there is tremendous idiosyncratic (i.e. person-specific) variation in the level of cognitive functioning among older people. Interestingly, intertemporal stability in individuals' relative intellectual functioning actually *increases* over the life cycle. (Herzog and Schaie 1986). At the same time, the degree of within-individual covariation between different intellectual abilities remains stable between middle and late adulthood (Baltes and Lindenberger 1997). Taken together, these considerations suggest that it remains very important for society to allow high-functioning older persons (of whom there will be many more as population health improves) to continue to work, manage, etc. as long as it remains efficient for them to do so.

6. Testing Hypotheses from Psychology with Economic Data: Some Results for Displaced Workers.

Since most of the previous section's results concerning aging and mental performance come from the psychology laboratory, their relevance to an aging

workforce's capacity to adapt to shocks is not immediate. Thus, to assess this relevance, in this section I "test" three key propositions from the psychology literature using data on displaced workers. Clearly, adapting to a new job after displacement may be the most dramatic and wrenching example of a case where an older worker needs to acquire a great deal of new knowledge, thus placing great demands on what psychologists call "brain plasticity", or "fluid intelligence".

According to my summary of the psychology literature, success in adapting to a forced job change should decline with age, holding other factors (including tenure on the lost job) constant. As noted, economists have paid little explicit attention to the role of age *per se* in displacement-induced job losses; I take a first step at correcting that imbalance here. The psychology literature also suggests that the age-related declines in adaptability noted above should be milder for (a) well-educated workers, and (b) women. I test these notions as well. The data I use are merged files from the U.S. Displaced Worker Survey from 1984 to 2000. To my knowledge this is the only North American data set with a large enough sample size to allow one to credibly distinguish age effects from tenure effects, and to credibly estimate interaction effects between age and other factors such as education and gender, once again holding tenure constant.

The purpose of Table 1 is to examine the "pure" effect of a worker's age on the magnitude of displacement-induced job losses in a way that requires a minimum of econometric and functional form assumptions. Tight controls for tenure are achieved by subdividing this sample of job losses by individual years of tenure on the lost job; thus (for example) the second row of Table 1 gives mean log wage changes for persons who involuntarily lost a job lasting between one and two years. The columns of the Table further subdivide the job losses by the worker's age when it occurred. Looking across the rows of the table, it is apparent that –while small sample sizes cause "noise" in places-- in almost all cases, older workers experience much larger wage losses upon displacement than younger workers. For example, after losing a job that lasted five years, workers in their 20's experience a log wage loss of .162, compared to .288 for workers in their 50's. Comparable figures for a job lasting twelve years are .213 and .446. I take this as supportive of the psychologists' notion that adaptability declines with age.[13]

Tables 2 and 3 address the effects of education and age on displacement-induced wage losses respectively. Here the controls for tenure are less fine –we simply restrict attention to jobs lasting between 8 and 12 years[14]-- allowing us to disaggregate education and age instead. While there are no clear differences between the three lowest education groups, Table 2 suggests that a university degree does make workers more adaptable: not only do such workers earn more to begin with, they also lose less (in percentage terms) when they are forced to change jobs. This difference across education groups is largest among the oldest workers. This is consistent with the notion in psychology that prior exposure to education preserves the brain's learning capacity. Finally, gender differences

[13] A skeptical economist would reply that, even when job tenure is held constant, age could be proxying for experience in an industry or occupation; thus it could be reflecting previous investments in industry-or occupation-specific skills. Further analysis that controls for these factors would clearly be of interest.

[14] The results are unchanged if we use regression to adjust for individual years of tenure within this 8-to-12-year range.

are examined in Table 3. Consistent with the psychological notion that older women may be more adaptable than older men, the results show considerably smaller wage losses for displaced older women than for displaced older men.

Clearly, there are other possible explanations for the above findings and more research on these questions needs to be done. They should be seen as illustrative of how psychology may provide hypotheses that are of interest to economists and to policymakers interested in the effects of workforce aging, and how these hypotheses can be tested with data that is familiar to economists.

7. Research Needs and Possible Policy Outcomes

Some important directions for further research have already been pointed out in our discussion of skill definition and measurement in Sections 2 and 3. For convenience, I begin this section by listing these directions, before turning to research needs emerging from our discussion of skills and aging. Important gaps in the Canadian literature on skills that, in my assessment, could contribute importantly to the formulation of a national skills strategy are (a) research on the role of parents' time investments in their children's long run skill development; (b) research on the role of "softer" skills, such as leadership, working in groups, "good work attitudes" etc.; and (c) research on the determinants of school performance in Canada using student testing data. All these research areas are relatively new to Canada compared to the U.S. A final area of particular interest to Canada, given its higher incidence of long-term unemployment than the U.S., is the importance of skill depreciation during unemployment spells.

In order to assess promising research directions related specifically to workforce *aging* and skill acquisition, it is helpful to first to summarize the literature review of the past three sections. As noted in that review, the aging of the Canadian workforce has certain inevitable implications for the workforce's ability to perform existing tasks and to learn new ones. Existing results from the psychology literature suggest that, in the medium term, aging will increase the stock of acquired knowledge ("crystallized intelligence") in Canada's workforce while reducing its average ability to acquire new knowledge ("fluid intelligence"). Psychology also suggests that performance in certain types of tasks, such as those that require softer personal skills such as wisdom and leadership, will survive the aging process better than those that require multitasking and the rapid assimilation of new facts and ideas. Compounding these developments, the existing economics literature points out that an older workforce, on average, is likely to have a higher average match quality. Like a higher level of general training, this increases productivity (indeed it is sometimes hard to distinguish empirically from general training) but has the distinguishing feature that –since match quality by definition is specific to *some* relationship (whether it be a firm, occupation or industry)—population aging means greater vulnerability to economic shocks: much more "cystallized intelligence" is lost due to obsolescence when an older workforce is buffetted by trade and technology shocks.

Counteracting the above sources of increased vulnerability, our literature review also points to a number of important mitigating factors. First, as noted, the shorter time horizons of older workers perhaps paradoxically provide a window of opportunity for Canada to specialize in the acquisition and use of "risky" skills with shorter expected half-lives, *despite* the lower capacity of older workers to acquire new knowledge. Investment in such skills makes particular sense for older workers whose "original" skills have been rendered obsolete by economic change; it may in fact make good economic sense to target retraining of older workers precisely into such high-risk tasks, occupations and industries. Second, improved health of older workers will make retraining easier for them than it once was; the entry of an especially healthy and adaptable group of older women may make the older workforce more flexible on average; and discoveries in the field of adult education are yielding improved learning results for older persons. In addition, simple economics implies that longer lifespans will raise the return to retraining for older workers, partially counteracting older workers' comparative advantage in riskier skills. Finally, as Kuhn and Sweetman (1999) have suggested, a lower historical level of actual (or perceived) job security and a greater level of multiskilling within their jobs may have induced the current generation of older workers to do a better job of maintaining their alternative competencies than the previous generation, so they may *already* be less vulnerable to economic shocks.

Supporting this discussion of mitigating factors, evidence that older workers are becoming more capable and adaptable than they once were comes from a number of recent labour market developments. Among them, after many decades of decline, the U.S. has recently seen a dramatic resurgence in the labour force participation of men between the ages of 66 and 70. While public policy (e.g. the treatment of earnings by the social security system) played some role in the former increase, Huneeus (2003) attributes this increase largely to an increase in *demand* for the labour of men over 65. Over the same period, the increased incidence of long (over 50 hours per week) work hours was greatest among men aged 55-64 than among any other age group (Kuhn and Lozano 2003). What seems particularly surprising about these changes is is the fact that they occurred during a period of, if anything, accelerating technological change.

Given the above state of knowledge on workforce aging and skill development, what types of research on this topic should be of particular interest to Canadian policymakers? Clearly, one need is for basic descriptive research, in part to confirm whether the U.S. trends documented in the preceding paragraph are also occurring in Canada, in part just to provide basic facts on aging and training. For example, do Canadian survey data show a resurgence of work among men over 65? Do they show increased incidence of retraining among older workers in recent years, and do they show faster within-cohort wage growth among older women than older men as is the cast in the U.S.?

A second contribution, not just to Canadian research but to the economics profession in general would be theoretical. As noted in Section 4, to my knowledge no one has yet worked out a model of the optimal timing of lifetime skill acquisition under uncertain skill demand. Given the discussion of the psychology literature in Section 5, it

would seem important to incorporate the possibility of age-related increases in learning costs into such a model.

Third, as noted, economists studying skill obsolescence (in particular using displaced-worker data) have paid surprisingly little attention to the role of age *per se* in the process of job loss, re-employment and retraining. Given the huge volume of psychological and physiological evidence that age plays a role in learning and in the performance of mental tasks, more attention to estimating these "pure" aging effects in the job market seems in order.

Fourth, as noted, while psychologists can tell us some things about the types of tasks older workers are (relatively) better at, neither the economics nor psychology literatures provides much concrete information about what types of jobs or occupations such tasks correspond to. (Which jobs use more "crystallized", versus "fluid" intelligence, for example? Which jobs use "risky" skills with a short expected half-life?). Without such knowledge, it will be difficult to know which occupations and industries are likely to experience a growing *supply* of qualified workers as a result of workforce aging. Thus, research that links skill types used in economics and psychology on the one hand with real-world occupations, tasks and industries would be very helpful.

Fifth, any discussion of a national skills policy also requires a better understanding of the changes in *demand* for skills, by type, in Canada. Thus, while a fair amount of consensus exists that recent technological change in all countries has been "skill-biased", recent analyses by Card and DiNardo (2002) and Lemieux (2004) have questioned the importance of this phenomenon, at least regarding the "residual" or "unobserved" component of skill within all population subgroups except the highly educated. Also, the notion that technological change is "skill-biased" is rather unhelpful in determining what *kinds* of skills are in increasing demand. More studies like Autor Murnane and Levy's (2003), especially for Canada, would be very useful in this regard.

Sixth, psychologists and others working in the field of adult education have done considerable research on "what works" in teaching concrete, measurable skills to older persons (both for job market purposes and at older ages). Aside from economists' studies of specific, federally-funded programs such as Trade Adjustment Assistance, to my knowledge economists have not addressed these issues. Studies by economists of the actual labour market consequences of different adult education strategies would seem to add important information here.

What policy changes might the federal government want to contemplate in formulating the national skills strategy of a country with an aging workforce? Given the limited state of our knowledge as summarized above, I would argue that *short term* policy and policy research should have two main components, the first of which is simply to *let market signals do their work*. In a free market economy, scarce skills *will* command higher prices which in turn induce workers to acquire them, whether as new entrants to the workforce or as displaced workers seeking an area in which to retrain. This process is likely to happen much more quickly than any economist can identify

which skill types are in increasing demand. Second, given the tremendous heterogeneity in job performance and learning ability among older workers, it is important to conduct a critical review of various aspects of federal policy –in particular income support policy—with a view to identifying and removing any unnecessary barriers to labour force participation among older workers. Older workers who wish to work and/or retrain should not be discouraged from doing so by the prospects of losing, say, CPP or other retirement benefits. Improving financing options for retraining among older workers may be reasonable short-term policy goals for the federal government as well.

I conclude this paper with a discussion of some *longer-term* policy changes that Canada should consider in formulating a national skills strategy. To some extent, these policy recommendations should be contingent on the outcomes of the research agenda sketched above; for that reason –and also because these are much more sweeping changes—they are necessarily more speculative than the short-term changes discussed above.

If research finds, as I expect but cannot prove, that the labour market of the future will place a much larger premium on "softer" interpersonal skills than harder "reasoning" skills (one can contract out the writing of software code to India but not clinical social work), substantial changes in education and retraining policy may be warranted. Just how to change Canada's schools and retraining programs to produce more of these skills is an area where economists, education researchers, psychologists, and adult education researchers might fruitfully collaborate.

Another long-run change that might be justified in a globalizing information economy is doing more to cultivate Canada's "top tail" of potential superstars. It is well known that both Canada and the U.S. have experienced a pronounced "fattening" of the right tail of the income distribution (Saez and Veall 2003); as a number of authors have noted this could be connected to an increase in the importance of low-marginal-cost information goods in today's economy. To my knowledge, however, only one study of the *acquisition* of "superstar" talent exists (MacDonald 1988), and it is completely theoretical. Especially to the extent that superstars play an important role in the production and export of high-value information goods (Grossman 2004), it may be more important than before to learn how a society can create and nurture its top tail of superstars. Policy may need to make Canada an attractive place from which superstars can serve world markets (see for example the recent models of international trade in information goods such as Manasse and Turrini (2001), and Kuhn and McAusland (2003).)

A final long term policy issue that should, in my assessment, form a part of the national discourse asks how Canada should respond to the possibility of long-term changes in the relative prices of capital and labour brought about by globalization. As noted, a highly-publicized trend in Silicon Valley involves the large-scale movement of highly paid computer programming jobs to Bangalore, India. India also has an emerging biotech industry that is exporting into the U.S. How does the discussion in this paper change when highly-skilled jobs *also* migrate to low-wage countries? One answer

(which presumes a unidimensional concept of worker skill) is that the only sure winner in such a world is capital: capital alone will capture the exceptional productivity gains that are now being realized via trade and technological advances. If this is true, Canada should take long term steps to insure broad ownership of capital among its population, exploiting the fact that it industrialized earlier than most countries to facilitate its transition into a "*rentier*" society with significant overseas assets owned by its population. In this view, large-scale immigration is probably not in Canada's long term interests. Or is the above view of skills too simplistic? Perhaps –despite their apparent prestige and high earnings—computer programming jobs have become relatively routinized, and the scarce skills of the future that will capture most of the productivity gains are "softer" skills like those involved in creativity, marketing and management. In this view, it is precisely these skills and not financial capital that hold the key to long term prosperity. Clearly, refining our concept of "skill" is critical to formulating a long-run economic vision for a developed, small, aging, and open economy like Canada's. I sincerely hope that the current paper has made some progress toward that goal.

References

Altonji, J. The Effects of High School Curriculum on Education and Labor Market Outcomes *Journal of Human Resources* 30(3) (Summer 1995): 409-438.

Altonji, Joseph G. and Shakotko, Robert A. "Do Wages Rise with Job Seniority?" *Review of Economic Studies*. July 1987; 54(3): 437-59

Arulampalam, Wiji "Is Unemployment Really Scarring? Effects of Unemployment Experiences on Wages" *Economic Journal.* November 2001; 111(475): F585-606

Autor, D., F. Levy, and R. Murnane, "The Skill Content of Recent Technological Change: An Empirical Exploration". *Quarterly Journal of* Economics 118(4) (November 2003): 1279-1334.

Autor, D., F. Levy, and R. Murnane. "Upstairs, Downstairs: Computer-Skill Complementarity and Computer-Labor Substitution on Two Floors of a Large Bank". NBER working paper no 7890, September 2000.

Baltes, P. B. and U. M. Staudinger. "Wisdom: a metaheuristic (pragmatic) to orchestrates mind and virtue toward excellence". *American Psychologist* 55 (2000): 122-136.

Baltes, P. and U. Lindenberger "Emergence of a powerful conection between sensory and cognitive functions across the adult life span: A new window to the study of cognitive aging?" *Psychology and Aging* 12 (1997): 12-21.

Barrick, M. R. and M. K. Mount. "The Big Five Personality Dimensions and Job Performance: A Meta-Analysis" *Personnel Psychology* 44 (1991): 1-26.

Becker, G. S., *Human Capital*, 2d ed., NBER, 1975.

Becker, Gary S.; Landes, Elisabeth M. and Michael, Robert T. "An Economic Analysis of Marital Instability" *Journal of Political Economy*. (Dec. 1977); 85(6): 1141-87.

Bedard, K., and C. Do. "Are Middle Schools More Effective? The Impact of School Structure on Student Outcomes" unpublished paper, University of California, Santa Barbara, 2004.

Ben Porath, Yoram.. "The Production of Human Capital and the Life Cycle of Earnings". Journal of Political Economy Vol. 75, No. 4, Part 1. (Aug., 1967), pp. 352-365

Bowles, S., H. Gintis, and M. Osborne, "The Determinants of Earnings: Skills, Preferences and Schooling". *Journal of Economic Literature* 39(4) (December 2001): 1137-1176.

Card, D. and J. DiNardo, "Skill-Biased Technological Change and Rising Wage Inequality: Some Problems and Puzzles". *Journal of Labor Economics* 20(4) (October 2002): 733-783.

Cawley, J., K. Conneely, J. Heckman and E. Vyactil, "Measuring the Effects of Cognitive Ability" National Bureau of Economic Research working paper no. 5645, July 1996.

Cerella, J. "Age effects may be global, not local: comment" *Journal of Experimental Psychology: General* (1991) (120): 215-23.

Chan, Sewin and Stevens, Ann Huff. "Job Loss and Employment Patterns of Older Workers" *Journal of Labor Economics* 19(2) (April 2001): 484-521.

Charness, N. and E. Bosman "Expertise and Aging: Life in the Lab", in. T. H. Hess, ed., *Aging and Cognition: Knowledge Organization and Utilization* Amsterdam: Elsevier, 1990, pp. 343-385.

Cho, Donghun. "Trends in U.S. College Enrollment, 1970-2000: Why Have Women Overtaken Men?" unpublished paper, University of California, Santa Barbara, August 2004.

Duncan, G. J. and R. Dunifon. "'Soft Skills' and Long-Run Labor Market Success". *Research in Labor Economics* 17 (1998): 123-149.

Educational Testing Service, "Learn More, Earn More?" *ETS Policy Notes* 9 (Summer 1999), pp 1-12.

England, Paula. "The Failure of Human Capital Theory to Explain Occupational Sex Segregation" *Journal of Human Resources*, Summer 1982; 17(3): 358-70

Farber, H. and R. Gibbons. "Learning and Wage Dynamics". *Quarterly Journal of Economics* 111 (November 1996): 1007-1048.

Farkas, G., P. England, K. Vicknair, B. Kilbourne, "Cognitive Skill, Skill Demands of Jobs, and Earnings among Young European, African American, and Mexican American Workers". *Social Forces* 75 (1997):913-940.

Farkas , G. and K. Vicknair, "Appropriate Tests of Racial Wage Discrimination Require Controls for Cognitive Skill: Comment on Cancio, Evans, and Maume" *American Sociological Review* 61 (1996):557-560.

Ferber, Marianne A. and Jane Waldfogel. "The Long-Term Consequences of Nontraditional Employment" *Monthly Labor Review*. May 1998; 121(5): 3-12

Finch, C. E. ""Biological Bases for Plasticity during Aging of Individual Life Histories". In D. Magnusson (ed.) *The Lifespan Development of Individuals: Behavioral, Neurobiological and Psychosocial Perspectives* New York: Cambridge University Press, 1996. pp. 488-511.

Galenson, David W.; Weinberg, Bruce A. "Age and the Quality of Work: The Case of Modern American Painters." *Journal of Political Economy* 108, no.4 (August 2000): 761-77

Goldin, Claudia and Lawrence F. Katz, "The Origins of Technology-Skill Complementarity", *Quarterly Journal of Economics* 113 (August 1998): 693-732.

Goldsmith, Arthur H; Veum, Jonathan R; Darity, William Jr. "The impact of psychological and human capital on wages" *Economic Inquiry* 35 (4), (Oct 1997):815-829.

Green, F., D. Ashton and A. Felstead. "Estimating the Determinants of Supply of Computing, Problem-Solving, Communication, Social and Teamworking Skills". *Oxford Economic Papers* 3 (2001): 406-433.

Gregory, Mary and Robert Jukes. "Unemployment and Subsequent Earnings: Estimating Scarring among British Men 1984-94" *Economic Journal.* November 2001; 111(475): F607-25

Grogger, J. and E. Eide, "Changes in College Skills and the Rise in the College Wage Premium," *Journal of Human Resources*, 30(2), (1995):280-310.

Grossman, Gene M. "The Distribution of Talent and the Consequences of International Trade" *Journal of Political Economy*. 112(1) (Feb. 2004): 184-209

Hartog. J. "On the Multicapability Theory of Income Distribution". *European Economic Review* 10 (1977): 151-171.

Heckman, James, and Jeffrey Smith. "The Determinants of Participation in a Social Program: Evidence from the Job Training Partnership Act," *Journal of Labor Economics*, forthcoming 2004.

Herrnstein, R. and C. Murray. *The Bell Curve: Intelligence and Class Structure in American Life*. New York: The Free Press, 1994.

Holmstrom, B. and P. Milgrom. "Multi-Task Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design". *Journal of Law, Economics and Organization* 7 (special issue, 1991): 24-52.

Holzer, H. *What Employers Want: Job Prospects for Less Educated Workers* New York: Russell Sage Foundation, 1996.

Hoyer, W. J. "Brain Aging (Norman): Behavioral, Cognitive, and Personality Consequences". in N. J. Smelser and P. B. Baltes, eds. *International Encyclopedia of the Social and Behavioral Sciences*. Oxford: Elsevier, 2001.

Huneeus, C. "Accounting for the Increase in Hours Worked among Older Men: US 1979-2002". Unpublished paper, Stanford University, November 2003.

Jencks, C. and M. Phillips, *The Black-White Test Score Gap*, The Brookings Institution Press, Washington D.C, 1998.

Hanushek, Eric A., and Margaret B. Raymond. "Does School Accountability Lead to Improved Student Performance?" NBER Working Papers no. 10591 (2004)

Hedges, L. and A. Nowell. "Sex Differences in Mental Test Scores, Variability, and Numbers of High-Scoring Individuals". *Science* 269 (1995): 41-45.

Herzog, C. and Schaie, K. "Stability and Change in Adult Intelligence: 1. Analysis of longitudinal covariance structures". *Pyschology and Aging* 1 (1986): 159-71.

Ilmarinnen, J. et al. "Changes in maximal cardiorespiratory capacity among aging municipal employees" *Scandinavian Journal of Work, Environment and Health* 17 (1991): 99-109.

Kamburov, G. and I. Manovskii. "Occupational Specificity of Human Capital". Unpublished paper, University of Western Ontario, 2002.

Kuhn, P. and F. Lozano. "The Rise in Long Work Hours among American Men, 1979-2002". Unpublished paper, University of California, Santa Barbara, 2003.

Kuhn, P. and C. McAusland. "The Storyteller's Tale: Gains from Trade in the Information Economy" unpublished manuscript, Univesity of California, Santa Barbara, 2003.

Kuhn, P. and A. Sweetman. "Use it or lose it? Human Capital Investment Strategies and the Earnings of Displaced Workers". Unpublished paper, University of California, Santa Barbara, 2003.

Kuhn, P. and C. Weinberger. "Leadership Skills and Wages" unpublished paper, University of California, Santa Barbara, 2004.

Krampe, R. T. *Maintaining Excellence: Cognitive Performance in Pianists Differing in Age and Skill* Berlin: Springer, 1994.

Kruse, A. "Adult Education and Training: Cognitive Aspects" in N. J. Smelser and P. B. Baltes, eds. *International Encyclopedia of the Social and Behavioral Sciences.* Oxford: Elsevier, 2001.

Lazear, E. "Firm-Specific Human Capital: A Skill-Weights Approach". NBER working paper no. 9679 (May 2003).

Lemieux, Thomas. "Residual Wage Inequality: A Re-examination". Unpublished paper, University of British Columbia, February 2004.

Lindenberger, U. "Lifespan Theories of Cognitive Development" in N. J. Smelser and P. B. Baltes, eds. *International Encyclopedia of the Social and Behavioral Sciences.* Oxford: Elsevier, 2001.

Lucas. R. E. B. "Hedonic Wage Equations and Psychic Wages in the Returns to Schooling". *American Economic Review* 67 (September 1977): 549-558.

MacDonald, Glenn M. "The Economics of Rising Stars" *American Economic Review* 78 (1) (March 1988): 155-166.

Maguire, Eleanor A. et al. "Navigation-Related Structural Change in the Hippocampi of Taxi Drivers" *Proceedings of the National Academy of Sciences of the United States of America* 97(8) (April 11, 2000): pp. 4398-4403

Manasse, Paolo, and Alessandro Turrini. "Trade, Wages and 'Superstars'" *Journal of International Economics* 54 (2001), pp. 97-117.

Medoff, James L, and Abraham, Katharine G. "Experience, Performance, and Earnings" *Quarterly Journal of Economics.* (Dec. 1980): 95(4): 703-36

Mincer, J. *Schooling, Experience, and Earnings.* New York: NBER, 1974

Murphy, K. M. and F. Welch, "Empirical Age-Earnings Profiles," *Journal of Labor Economics* 8, April 1990, 202-229.

National Association of Colleges and Employers, "Ideal Candidate Has Top-Notch Interpersonal Skills, Say Employers". January 18, 2000. Posted at http://www.jobweb.org/pubs/pr/pr011800.htm).

Neal, D. and W. Johnson, "The Role of Pre-Market Factors in Black-White Wage Differences" *Journal of Political Economy* 104(5) (October 1996): pages 869-95.

Neal, D. "Industry-Specific Human Capital: Evidence from Displaced Workers" *Journal of Labor Economics.* October 1995; 13(4): 653-77

O'Neill, J. "The Role of Human Capital in Earnings Differences between Black and White Men" *Journal of Economic Perspectives*, 4 (1990):25-45.

Paglin, M. and A. Rufolo, "Heterogeneous Human Capital, Occupational Choice, and Male-Female Earnings Differences." *Journal of Labor Economics* 8 (1990):123-144.

Papalia, Diane et al., *Adult Development and Aging* (2nd edition) Boston: McGraw Hill, 2002.

Parent, Daniel. "Industry-Specific Capital and the Wage Profile: Evidence from the National Longitudinal Survey of Youth and the Panel Study of Income Dynamics" *Journal of Labor Economics* 18(2) (April 2000): 306-23.

Pasupathi, M., U. Staudinger and P. Baltes. "Seeds of wisdom: Adolescents' knowledge and judgement about difficult life problems" *Developmental Psychology* 37 (2001): 351-361.

Pinker, Steven. *How the Mind Works*. New York: Norton, 1997.

Richtel, Matt. "Computer screening of job seekers has risks". *Santa Barbara News-Press*, February 6, 2000, p. A1.

Ruhm, C. "Are Workers Permanently Scarred by Job Displacements?" *American Economic Review* 81(1) (March 1991): 319-24

Ruhm, C. "Parental Employment and Child Cognitive Development". *Journal of Human Resources*, forthcoming 2004.

Saez, E. and M. Veall. "The Evolution of High Incomes in Canada, 1920-2000". NBER Working Paper No. w9607, April 2003

Schneider, K. "The Significance of Learning for Aging". *Educational Gerontology* 29(10) (2003): 809-823.

Scoville, James. *The Job Content of the U.S. Economy 1940-1970*. New York: McGraw-Hill, 1969.

Scoville, James. *The Job Content of the Canadian Economy, 1941, 1951 and 1961*. Ottawa: Dominion Bureau of Statistics, Special Labour Force Study no. 3, April 1967.

Shaw, Kathryn. "A Formulation of the Earnings Function Using the Concept of Occupational Investment" *Journal of Human Resources*. Summer 1984; 19(3): 319-40

Simonton, Dean K. "The Swan-Song Phenomenon: Last-Works Effects for Classical Composers" *Psychology and Aging* 4 (1989): 42-47.

Simonton, Dean K. "Creativity and Wisdom in Aging" in J. E. Birren and K. W. Schaie (eds), *Handbook of the Psychology of Aging*. New York: Academic Press, 1990 (pp. 320-329).

Spenner, K. I. "Temporal Changes in Work Content". *American Sociological Review* 44 (6) (December 1979): 968-975.

Sternberg, Robert. *The Triarchic Mind: A New Theory of Human Intelligence*. New York: Viking Penguin, 1988.

Stevens, Ann Huff. "Persistent Effects of Job Displacement: The Importance of Multiple Job Losses" *Journal of Labor Economics* 15(1) (January 1997): 165-88.

Sweetman, Arthur. "Immigrant Earnings: Age at Immigration Matters" (with Joseph Schaafsma) *Canadian Journal of Economics*, 34(4) (2001): 1066-99

Tett, R. P., D. N. Jackson, and M. Rothstein. "Personality Measures as Predictors of Job Performance: A Meta-Analytic Review" *Personnel Psychology* 44 (1991): 703-742.

Topel, R. "Specific Capital, Mobility, and Wages: Wages Rise with Job Seniority". *Journal of Political Economy* 99 (February 1991): 145-176.

Weinberger, Catherine. "Mathematics Test Scores, Gender, Race, Ethnicity and the Science and Engineering Workforce". Unpublished paper, University of California, Santa Barbara, February 2000.

Weinberger, Catherine and Peter Kuhn. "The Mid-Life Recovery in Women's Earnings". work in progress, University of California, Santa Barbara.

Williams, Donald R. "Consequences of Self-Employment for Women and Men in the United States" *Labour Economics.* September 2000; 7(5): 665-87

Willis, S. L. "Cognitive Training and Everyday Competence" *Annual Review of Gerontology and Geriatrics* 7 (1987) 159-80.

Willis, S. L. and Schaie, K. W. "Intellectual Functioning in Mid-Life" in S. L. Willis and J. D. Reid (eds) *Life in the Middle: Psychological and Social Development in Middle Age* San Diego: Academic Press, 233-247.

Woodruff-Pak, D. S. and S. K. Lemieux. "Memory and Aging, Neural Basis of", in N. J. Smelser and P. B. Baltes, eds. *International Encyclopedia of the Social and Behavioral Sciences*. Oxford: Elsevier, 2001.

Table 1: Mean Log wage changes of displaced workers, US displaced worker surveys, 1984-2000

Tenure at Displacement (years)	Age at Displacement			
	20-29 yrs	30-39 yrs	40-49 yrs	50-59 yrs
0	-0.045 (1,748)	-0.067 (1,306)	-0.101 (602)	-0.154 (240)
1	-0.034 (1,615)	-0.083 (1,331)	-0.119 (679)	-0.084 (219)
2	-0.064 (1,411)	-0.087 (1,265)	-0.123 (635)	-0.213 (264)
3	-0.138 (934)	-0.154 (967)	-0.123 (498)	-0.210 (232)
4	-0.142 (523)	-0.108 (536)	-0.115 (299)	-0.174 (136)
5	-0.162 (456)	-0.158 (581)	-0.226 (332)	-0.288 (167)
6	-0.162 (283)	-0.240 (295)	-0.183 (197)	-0.182 (68)
7	-0.129 (185)	-0.199 (305)	-0.316 (191)	-0.273 (70)
8	-0.222 (142)	-0.201 (262)	-0.249 (165)	-0.319 (78)
9	-0.158 (77)	-0.186 (214)	-0.320 (122)	-0.352 (51)
10	-0.337 (133)	-0.226 (273)	-0.281 (166)	-0.393 (108)
11	-0.053 (34)	-0.206 (147)	-0.218 (79)	-0.283 (34)
12	-0.213 (22)	-0.335 (149)	-0.253 (103)	-0.446 (52)
13	-0.130 (13)	-0.229 (162)	-0.370 (99)	-0.376 (48)
14		-0.324 (101)	-0.300 (69)	-0.255 (39)
15		-0.285 (137)	-0.332 (107)	-0.423 (54)
16		-0.244 (64)	-0.420 (56)	-0.354 (30)
17		-0.274 (72)	-0.281 (82)	-0.414 (34)

18	-0.334 (64)	-0.333 (65)	-0.263 (31)
19	-0.386 (31)	-0.419 (50)	-0.483 (23)
20	-0.645 (42)	-0.292 (95)	-0.363 (47)

Sample sizes in parentheses. Cells with 10 or fewer observations not reported. Tenure of "0" implies under one year; 1 implies between 1and 2 years, etc.

Table 2: Mean log wage change after losing a job lasting 8-12 years, by education and age, US Displaced Worker Surveys

	Age		
	33-42	**43-52**	**53-62**
High School Dropout	-.251 (103)	-.376 (82)	-.417 (44)
High School Graduate	-.253 (357)	-.286 (183)	-.399 (84)
Some College	-.269 (244)	-.256 (124)	-.429 (50)
College Degree	-.199 (234)	-.247 (129)	-.226 (51)

Table 3: Mean log wage change after losing a job lasting 8-12 years, by gender and age, US Displaced Worker Surveys

	Age		
	33-42	**43-52**	**53-62**
Men	-.272 (619)	-.271 (298)	-.430 (135)
Women	-.189 (319)	-.300 (220)	-.285 (94)

Figure 1: Age and performance on psychological tests

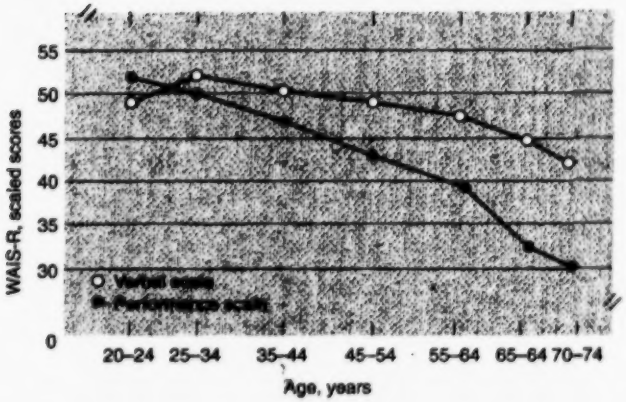

FIGURE 6.3 ***Classic aging pattern on the revised version of the Wechsler Adult Intelligence Scale (WAIS-R).*** Scores on the performance subtests decline far more rapidly with age than scores on the verbal subtests.

SOURCE: Botwinick, 1984.